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USAISEC

US Army Information Systems Engineering Command
Fort Huachuca, AZ 85613-5300

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TECHNOLOGY ASSESSMENT OF MAN MACHINE INTERFACE

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AIRMICS
115 O'Keefe Building
Georgia Institute of Technology
Atlanta, GA 30332-0800

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THIS REPORT HAS BEEN REVIEWED AND IS APPROVED

s/ Glenn E. Racine, Chief
Computer and Information
Systems Division

s/ John R. Mitchell
Director
AIRMICS

Technology Assessment: Man-Machine Interfaces

I. Historical Review

Interfaces, also called man-machine interfaces or input-output (I/O)mechanisms, are the means by which humans communicate with computer resources and applications. In the first two decades of computer development (1950's and 1960's), interfaces designed for general purpose, end-user application were very primitive. Card readers, card punch machines and hard copy printer terminals were the predominant man-computer interface devices. Since the late 1960's, keyboards and monitors have been the dominant communications interface between the computer and the user in an increasingly more interactive environment. Throughout most of this period of development, the user has been required to have significant training and knowledge of the specific hardware, operating system and application in order to use the computer. As the use of computers began to proliferate during the 1970's, the demand for simpler, more easily learned interfaces began to grow.

This demand has effected significant changes in the design of interfaces, particularly through the influence of ergonomic considerations in these designs. The current trend in man-machine interfaces, addresses sensory capabilities beyond the tactile, particularly the use of speech and vision as a medium. This paper will address those trends and examine the near term implications of these trends on the automated systems developed in the near term (3-5 years), short term (6-10 years) and long term (2010).

Many interface mechanisms, both hardware and software, that are available today were actually developed and have been widely used in the academic and research communities for many years. Bit mapped graphics--a high speed method for screen display in which the enire screen image is stored explicitly in an area of memory called

a bit map, where each screen pixel (dot of light) location has a one-to-one mapping to a counterpart in memory --light pens and mice, icon graphics and windowing interfaces have been used in these communities for 15 years or more. During this period, interface mechanisms were hand-crafted on an ad-hoc basis for the specific application, usually on powerful workstations or terminals to powerful mini- or mainframe computers. These interfaces were designed generally to increase productivity by minimizing the level of "housekeeping" chores necessary to use the system. Over a period of time, many of these techniques were collected into integrated "toolkits" that became more commonplace within the academic and research communities. Most of these toolkits included the use of a mouse, icon graphics, and sophisticated methods, such as hypertext, to access different levels of information.

Hypertext, or its more generalized form, hypermedia, is an approach to information management in which data is stored in a network of nodes connected by links. These nodes can contain graphics, text, video or other forms of data, and are generally viewed and manipulated through a windows-like interactive browser. It has only been over the past decade, that a trend toward "user-friendly", more intuitive interfaces like these that provide both easier accessability to the application and greater transparency to the hardware and operating system for the user has become prevalent. Much of the impetus for this has been the widespread proliferation of end-user computing that was effected by the "micro-computer revolution" of the early 1980's. This proliferation of relatively inexpensive microcomputers has exposed a growing number of technically unsophisticated users to increasingly more powerful computer resources. This environment, in which a greater number of relative computer amateurs are being required to apply increasingly greater emphasis on automated solutions to an increasing level of daily business activities, requires that the man-machine interface become even more powerful, intuitive and easier to use than previously required.

II. Currently Available Man-Machine Interface Technology.

This section will address the capabilities and limitations of a number of man-machine interface technologies that are currently available.

A. Capabilities of current man-machine interface technology.

Hardware or mechanical interfaces include a plethora of technologies from keyboards, number pads and monitors on the low end of the technology, to the more technically sophisticated options such as optical character readers/ scanners, voice recognition/synthesis, and electrical/ mechanical pointing devices such as the mouse, light pens, touch sensitive screens, writing tablets, trackballs and joysticks. The development of these devices illustrates a recognized need for making the human-machine interaction both physically and psychologically less arduous. Most of these require software interface counterparts to augment the ease of use. An example is the use of menu screens or graphic icons in conjunction with pointing devices such as the mouse, light pen or touch sensitive screen. Voice recognition and synthesis interfaces have only recently become commercially available. The former is a interface method in which human speech is digitized and translated into machine readable instructions. Examples of this technology include Kurzweil's Voicesystem and Voiceterminal products and Roar Technology's Voicekey board, each of which support a vocabulary of over 1000 words. Speech syntheses is an output interface in which the machine communicates with the user by translating machine readable information into understandable human speech.

Software/graphics interfaces include a variety of approaches to creating a more 'transparent' environment for the user-- avoiding (as much as possible) the need for interacting with the housekeeping functions of the operating system/hardware through the use of standardized, reasonably intuitive graphics through which the user interacts with the application. The development of windowing interfaces--a bit mapped display of

variable size, shape and location on the screen, in which information is displayed--reflects the increasing significance placed on presenting an intuitive, easy to use and understandable interface. MS-Windows and Presentation Manager for personal computers and various X-Windows based graphics for Unix machines are examples of this technology. The integration of these software interfaces with the pointing devices described above further enhances the growing ease of use of computers for end users. Additionally, an increasing number of products are beginning to introduce limited "natural language" front ends either to the application or the interface environment (eg windows) to reduce the user's requirement for detailed knowledge of the syntax required to use the operating system or to execute the application.

B. Limitations/quality of current man-machine interfaces.

Optical/Mechanical Interfaces Input devices. Despite the existence of mechanical interface devices for 10-15 years, widespread support of these products by software developers has limited both the acceptance and innovative use of these. An example of the use of the mouse as a pointing device clearly illustrates this point. The mouse is a de facto standard on most high end workstations, generally integrated both within the system interface and the application environment. Within the general purpose personal computer environment, however, only a very limited number of applications (Macintosh, GEM) have been developed with an eye toward the use of these devices. The Macintosh line of computers (and support software) has made significant inroads in developing credibility for this technology. Optical input devices provide a useful data transfer alternative to keyboard input from a paper medium to electronic form. The fastest and most economical way to perform this transfer is to convert non-electronic data to a digital format through scanning. The three primary methods of optical recognition include bar coding, scanning and optical character reading. Bar coding is a widely used method that employs a pattern of dark and light lines of different widths as code for

information. It is particularly popular for inventory functions. The remaining two methods are digital and digitized scanning. Digital scanners are called optical character readers (OCR). They read individual characters and encode them into binary, machine-readable form. OCR's distinguish between different characters and fonts and can generally adapt the transfered data to popular word processing packages. Digitized scanners convert a document into picture elements called pixels. This data must be indexed for retrieval because it does not distinguish between individual characters. Scanning is the faster, but less accurate method, and OCR is in effect an implementation of the scanner technology, in which sophisticated algorithms are employed to determine the specific character being translated. Optical scanning is not a mature technology. A number of limitations affect the widespread use of this technology, including:

a. a lack of standards for image scanning output formats or the scanned image storage format,

b. scanning devices generally run software that serve a limited number of commercial applications,

c. digital scanners are limited to the recognition of specific fonts and styles (proportional and dot matrix print are virtually unreadable) and tend to be error prone,

d. the storage requirements for digitized documents is significant.

Speech recognition systems have made significant progress in just the past 2-3 years. Impressive strides have been made, particularly in increasing the size of usable vocabularies for isolated (carefully articulated single words) speech. The importance and progress of this technology are well illustrated in the recently introduced NEXT computer which employs voice I/O technologies for voice mail. Despite this, significant improvements are required both in expanding the vocabulary of the system (currently

limited to approximately 1000 words) and more accurate recognition of continuous or connected speech input both from different users and in noisy environments. Output Devices. Despite the growing popularity of Enhanced Graphics Adapter (EGA) and Video Graphics Array (VGA) color medium to high-resolution graphics monitors, the most common output interface device on general purpose personal computers remains (primarily due to low price) the low-to-medium resolution (640 x 400 or less pixel resolution) monochrome monitor. Use of the color graphics adapter (CGA) monitor is also relatively widespread.

The predominant low end system interface continues to be either arcane operating system command languages (DOS, UNIX) or menu-driven interfaces. The former requires a significant level of technical knowledge to execute applications and perform housekeeping activities. The latter severely limits the user's ability to concisely communicate requirements to the system that are not exactly delineated by the menu interface. The current generation of high end system interfaces are best characterized by Apple Computers Macintosh line, the Digital GEM and Microsoft Windows environments. The integrated use of somewhat descriptive icons with pointing devices and a windowing environment has set a direction and minimum standard for future industry developments. The limited widespread exploitation of these features by application developers is a significant limitation to acceptance and use. Additionally, the current generation of windowing interfaces presently lack the ability to tie together applications.

C. Application to the IMA.

The increased use of currently available interface technology can effect significant productivity improvement by making automation resources easier to learn and use. Intuitively, this would lead to reduced time and costs for training. Continued improvements in the design of interfaces is increasing this level of transparency of the

underlying operating systems, hardware and programing languages. Commercial (if non-standard) program application interfaces are currently available to tie disparate applications together under a single global interface. Examples of this include the integrated business software from Lotus (Symphony), Ashton-Tate (Framework) and MDBS (Knowledgeman and Guru). The current generation of optical scanner devices can provide significant savings and increased productivity in data translation efforts.

III. Man-Machine Interface Technologies in the Near Term (1995)

This section addresses new developments in man-machine interfaces that will make a significant impact within the next 3-8 years. Realistically, much of the MMI technology that is beginning to be introduced or become commercially available today will not be in widespread use, particularly in the Army, for another 2-5 years. This lag time in the transfer of technology from the business community into the Army is due primarily to the procurement processes involved in making this transfer.

A. Capabilities of man-machine technologies in the near term.

1. Hardware interfaces.

The most significant improvement in interface technology will be the commonplace existence of integrated standard tools at each workstation, much like those found on powerful workstations in current research and academic facilities. Many of the tools prevalent on workstations today will become commonplace standards for the office/administrative workstation. These include a mechanical pointing device such as the trackball or mouse, a robust voice recognition system (limited to a small command set) for vocal input directly into the application (or system interface), high resolution (1024 x 1024 or greater) full page, color display screens, local area network (LAN) access to both document scanning and optical character reader equipment (input) and inexpensive, high speed laser-quality printers or color screen projection equipment

(output). Each of these technology areas are detailed below.

a. Optical I/O Technology. Optical I/O technologies fall into two broad categories: 1) Direct human-machine interfaces in which optical transceivers are used to detect and translate user eye movement to specific screen locations (coordinated with either vocally or mechanically directed execution) and 2) optical scanning devices which translate information from one media (usually paper) into an electronic form for manipulation. Prototype direct optical interfaces are currently under development. Analytics has been working on an Ocular Attention-Sensing Interface System (OASIS) for over 3 1/2 years. OASIS has been used in conjunction with voice-recognition technology in a variety of functions including vehicle and robot control, and inputting and manipulation of simulations and conventional business software applications (databases and spreadsheets). These devices will be commercially available in the next 3-4 years, however, the hardware requirements for the transceivers and calibration equipment will limit their use, at least in the near term, to high-end workstations. Examples of optical scanning devices include the document scanners and optical character readers (OCR) previously discussed. The scanner will become a generic input device that can be used with any software following the consolidation of image scanning and OCR technologies with facsimile transmission technology.

b. Voice I/O Technology. Both voice recognition and voice synthesis systems will be well established commercial products. Voice recognition technology will be well established in manufacturing and process control environments. Relatively robust isolated and connected speech interfaces will be commercially available for general purpose business applications (database, graphics, communications) and will be widely integrated with digital voice communications (voicemail, digitized voice-print security).

2. Software Interfaces.

The software interfaces prevalent on general purpose computer systems in the near term will strongly resemble the environments found on the current generation of top-end,

high powered workstations such as the Symbolics, Apollo and larger Vax and Sun systems. PC systems (predominately Motorola 68000+ and Intel 80386 microprocessor-based equipment) will employ Microsoft Windows/Presentation Manager style windowing environments that employ descriptive icon graphics to assist the user in navigating the system. Some of these icons will have the appearance of familiar equipment and employ graphics that resemble common objects and tools used in day to day activity. The window interface will possess a greater ability to tie applications together. The operating system command language will become both less arcane and less available to the end user due to the insulating effect of natural language and graphic interfaces that will make the operating system more transparent to the user. Underlying these graphic interfaces will be a growing level of computer-as-assistant role that will integrate computer assistant instruction modules controlled by expert/knowledge based modules with the system interface. This assistant role of the interface environment will provide the user with assistance in selection of correct tools for a particular application, instruction for employing the tool and guidance during the use of the tool (e.g. on-line syntax/semantics checking, hueristic-based answering capibility in response to user-generated "how" and "why" questions).

High density graphic screens will provide the necessary palette for animated presentation graphics, sophisticated development tools (computer assisted design (CAD), computer assisted software engineering (CASE), decision support systems (DSS)) and visually 'sharing' activity between activities running in separate windows. These will be enhanced for audience viewing (e.g. formal presentations or training) with high-resolution screen projection systems.

B. Performance/Quality of man-machine interfaces in the near term.

The greatest potential for advanced man-machine interfaces will result from the integration of multiple interface technologies that overcome each other's limitations.

The user is provided with a kind of three-dimensional simulation of the familiar office environment through the integration of these technologies enhanced with techniques from artificial intelligence (e.g. expert system control of the various elements of the interface), object oriented programming (optimizing re-use of components, providing an integrating environment for diverse components) and graphics methodologies.

C. Application to the IMA.

The widespread use of 'point and execute' devices, robust voice recognition and synthesis tailored to thespecific application, standardized window-based, iconic graphics in a multi-processor environment will showcase the continued transition of the interface technology currently available on hi-powered workstations to the end user/ developer environment. These capabilities will provide increasing consistency in user-machine dialogue, minimizing the requirement to retrain users between different systems and reducing the cost of training new users. Reduced costs in data translation between disparate media (e.g. paper and electronic) will continue to be realized as scanner/OCR technologies continue to mature.

IV. Man-Machine Interface Technologies in the Long Term (2010)

This section will examine developing technology that will have an impact on man-machine interface systems in the early 21st century.

A. Capabilities of man-machine technologies in the long term.

1. Hardware

In the long term, an increased sophistication of OCR/Text recognition will become available through the use of hueristic/ cognitive based algorithms. High resolution displays will be common-place and will integrate automation with communications, particularly digitized television images within windows on the display. Continuous

speech voice recognition interfaces will virtually replace keyboards as the primary human-computer interface. Current research in electroencephalographic control of interface devices -- mechanisms that are activated by devices that detect electrical brain activity and translate this activity into simple commands-- will produce the initial generation of commercial electroencephalographic interface products. These will probably become available first in the area of vehicle and robot control and will begin to be explored for at least simulation programs and control of icon graphics.

2. Software.

The greatest advances will be in the use of increasingly sophisticated natural language capabilities integrated with both the system and application interfaces. Direct access to the operating system and control of devices through command languages will become virtually obsolete. The increasing distributed nature of automation will require further sophistication in system-level interfaces that insulate the user from a requirement to know any details about the distributed nature of the environment. Access to remote databases, equipment, systems etc., will be a function of virtual windows driven by underlying knowledge-based software rather than user control. As the system environment continues to become more complex, the interface mechanisms will present an increasingly more intuitive, non-technical user environment. The primary screen/system interface will be an integrating environment to provide applications access, training, presentation graphics and activity assistance support to the user.

B. Application to the IMA.

Software interfaces will provide a de facto standard to tie applications together and provide a common environment for a broad base of users. This common environment, supported by both knowledge based control and explanation features and robust natural language capabilities will further reduce the requirement for retraining users from system to system (and associated costs), minimizes the impact of employing disparate

applications packages from different vendors, and provides a common and familiar interface amoung different applications. This environment will provide the mechanism to integrate the entire spectrum of the IMA, including printing and publishing, records management and audio-visual, communications (digitized voice mail, electronic mail, network interaction) and automation requirements. The widespread use of continuous voice technology especially coupled with ocular interface devices, will eliminate the requirements for cumbersome keystrokes or button oriented command and control systems to operate an application or operating system. This will in turn, further impact on both reducing training and operational costs and enhancing user productivity.

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